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PATENT SPECIFICATION

625,579

Convention Dates (France)

Sept. 5, 1945.
June 17, 1946.

Corresponding Applications in United Kingdom

No. 22678/46
No. 22679/46 } dated July 30, 1946.

(One Complete Specification left under Section 91 (2) of the Patents and Designs Acts, 1907 to 1946).

Specification Accepted: June 30, 1949.

Index at acceptance:—Class 4, A3c4, B(8: 11b), I7a1, I8j(1: 2).

COMPLETE SPECIFICATION

ERRATA

SPECIFICATION No. 625,579.

Page 1, lines 38—39, *for* " requirement " *read* " requirements "
Page 1, line 40, *for* " wing " *read* " wings "
Page 2, line 67, *after* " lift " *insert* " to "
Page 5, line 11, *for* " with a lower " *read* " with low "
Page 5, line 126, *for* " wig " *read* " wing "
Page 5, line 127, *for* " at " *read* " to "
Page 6, line 105, *for* " and-or " *read* " and/or "

THE PATENT OFFICE,
1st *November*, 1951.

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system of an aircraft, since the induced drag decreases as the aspect ratio increases.

However, hitherto, it has been the practically universal opinion of men skilled in the art that there was an upper practical limit to the actual values of the aspect ratio in all engine propelled heavier than air aircraft, this limit ranging from 10 to 20; in fact, there does not exist, among successful power propelled aircraft of this type, any practical example of aspect ratios above these values, which have been considered critical.

The reason for this has been that the use of aspect ratios above these values involved, due to constructional requirement, the necessity of increasing the weight of the wing to such a degree that the gain of aerodynamic efficiency was more than counterbalanced by the detrimental consequences of this increase in weight.

I have found that this apparently insuperable obstacle to the otherwise desirable increase of the aspect ratio can

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example, and in which:

Figs. 1 and 2 diagrammatically show, in front view and in plan view respectively, an aeroplane made according to a first embodiment of my invention;

Figs. 3 and 4 are similar views of a second embodiment;

Fig. 5 shows, on a large scale, the skeleton of a wing of an aeroplane constructed according to my invention;

Fig. 6 is a section on the line VI—VI of Fig. 5, this skeleton being covered with reinforcing plates;

Fig. 7 is a diagrammatic front view of part of an aeroplane having wing bracings as shown by Fig. 1;

Fig. 8 is an end elevational view of the wing of this aeroplane;

Figs. 9, 10, 11 and 12 indicate the shapes of different sections, on the lines A—A, B—B, C—C and D—D respectively of Fig. 7, of a wing bracing strut,

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COMPLETE SPECIFICATION

Improvements in Aircraft

I, MAURICE LOUIS HUREL, a citizen of the French Republic, residing at 21, Rue Gontrand-Biron, Deauville (Calvados), France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to aircraft, and its object is to ensure a substantial improvement of the aerodynamic properties of aircraft over those obtained with the conventional construction at present in use.

It is well known that such improvements, and in particular an increase of the lift to drag ratio and of the power coefficient (i.e. the ratio of the cube of the lift coefficient to the square of the drag coefficient) will be obtained by increasing the geometric aspect ratio of the wing system of an aircraft, since the induced drag decreases as the aspect ratio increases.

However, hitherto, it has been the practically universal opinion of men skilled in the art that there was an upper practical limit to the actual values of the aspect ratio in all engine propelled heavier than air aircraft, this limit ranging from 10 to 20; in fact, there does not exist, among successful power propelled aircraft of this type, any practical example of aspect ratios above these values, which have been considered critical.

The reason for this has been that the use of aspect ratios above these values involved, due to constructional requirement, the necessity of increasing the weight of the wing to such a degree that the gain of aerodynamic efficiency was more than counterbalanced by the detrimental consequences of this increase in weight.

I have found that this apparently insuperable obstacle to the otherwise desirable increase of the aspect ratio can actually be overcome by the use of external wing bracings and increasing the wing loading beyond the figure hitherto employed, so that it becomes possible to use aspect ratios of values far exceeding those considered as practically possible up to now, while keeping most of the advantages inherent in the use of high aspect ratios.

Thus, in this invention I provide a power propelled aircraft having fixed wings and external bracings therefor, said bracing serving as auxiliary lifting surfaces and the aspect ratio of the whole lifting surfaces (i.e. b^2/S, where be is the span and S the total area of the wing system) is not less than 15 under all circumstances of flight, and the wing loading (including that of the auxiliary lifting surfaces) being not less than 80 kgs. per square meter.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings, given merely by way of example, and in which:

Figs. 1 and 2 diagrammatically show, in front view and in plan view respectively, an aeroplane made according to a first embodiment of my invention;

Figs. 3 and 4 are similar views of a second embodiment;

Fig. 5 shows, on a large scale, the skeleton of a wing of an aeroplane constructed according to my invention;

Fig. 6 is a section on the line VI—VI of Fig. 5, this skeleton being covered with reinforcing plates;

Fig. 7 is a diagrammatic front view of part of an aeroplane having wing bracings as shown by Fig. 1;

Fig. 8 is an end elevational view of the wing of this aeroplane;

Figs. 9, 10, 11 and 12 indicate the shapes of different sections, on the lines A—A, B—B, C—C and D—D respectively of Fig. 7, of a wing bracing strut,

in the respective positions they occupy with respect to the wing shown by Fig. 8;

Fig. 13 is a sectional view of a form of wing according to the invention;

Fig. 14 is a section on the line J—K of Fig. 13.

Fig. 15 is a perspective view of part of a wing provided with a lift increase device included in this invention;

Fig. 16 shows means for controlling the device indicated in Fig. 15.

In order to obtain a useful improvement in lift to drag ratio and power coefficient resulting from the choice of a high geometrical aspect ratio, the angle of incidence of the wing system according to my invention should have for normal flying conditions, a high value corresponding to a lift coefficient, higher than 0.5 and possibly as high as 1.1 or more.

The aerofoil section camber will advantageously be chosen rather high, according to the intended use of the aircraft. This camber may be as high as 8—10%. Furthermore, I preferably choose aerofoil profiles of medium thickness (from 10 to 14%) and of substantial curvature. Among the aerofoil profiles that seem to be particularly well adapted for use according to my invention is the Saint-Cyr 109 or the Sikorsky GS 1 aerofoil profile. Such an aerofoil will give, for a lift coefficient of 1 and an aspect ratio of 30, a lift to drag ratio of 47 and a power coefficient of 2000, whereas the usual values are respectively 25 and 400 for aspect ratios ranging from 6 to 8.

In order to ensure a relatively low take off and landing speed of the aircraft despite the reduction of area of its wing system, according to one of the features of my invention, I provide the wing with a lift increase device, having a high lift coefficient (from 3 to 5 for instance) and a low drag coefficient.

It should be noted here that the high aspect ratio of the wing has a very advantageous influence upon the reduction of the drag produced by the lift increase device. This is due to the fact that most of the drag of wing systems fitted with lift increase devices is constituted by induced drag. If the lift increase device is fitted on a wing system of high aspect ratio, the induced drag is greatly reduced and the lift to drag ratio and power coefficient of this wing system may be normal, despite the presence of the lift increase device, which permits a quick take off at a low speed. For instance, a wing fitted with a lift increase device giving a lift coefficient of 4 and the corresponding profile drag coefficient of which is equal to 0.09 has, for an aspect ratio of 30, a total drag coefficient of 0.25, whereby its lift drag ratio is equal to 16 and its power coefficient is equal to about 1000. If the said lift increase device were fitted on a wing of an aspect ratio of 6, the value of the drag coefficient would have been 0.89 instead of 0.25.

It is pointed out that the fact that the wing area is reduced by modifying the chord whilst using a span of normal value not only has for its effect to avoid an excessive wing weight but also permits of substantially increasing the maximum speed and the cruising speed of the aeroplane. Furthermore, it permits of reducing the area of the tail unit and the length of the fuselage, which involves a supplementary reduction of the head resistance and weight of the aeroplane.

As has been stated, the wing is, in this invention, provided with bracings. Although these bracings give rise to a supplementary drag, the latter is very much smaller than the gain ensured, especially in the case of high lift coefficients, because the high aspect ratio obtained involves a substantial reduction of the induced drag.

In the embodiment of Figs. 1 and 2, I provide two under side struts 1 between the wing 2 and the fuselage 3. If, for instance, the wing of this aeroplane has an area of 12 sq. m. and a span of 20 m., and thus an aspect ratio of 33, and the two struts 1 are each 4 m. long and 50 mm. thick, the C_D of the struts will be about 0.002. Under these conditions, the gain of C_D, with respect to a wing of an aspect ratio of 8, is 0.01 for a C_L of 0.5, 0.04 for a C_L of 1 and 0.0575 for a C_L of 1.2.

Thus an aeroplane as illustrated by Fig. 1, if given the dimensions above indicated and furnished with an engine of 500 HP, can be loaded to a weight of 3 tons. Its maximum speed will reach 400 km. per hour, and its ceiling will be 12,000 m. with a useful load of 800 kg. A power of 200 HP will be sufficient at ground level for flying at 220 km. per hour or a power of 160 HP for flying at 360 km. per hour at an altitude of 10,000 m. This power will be easily supplied by the engine if it is provided with a compressor restoring the power of 500 HP at an altitude of 5,000 m.

Figs. 3 and 4 indicate an aeroplane with a wing span of 60 m. and a wing area of 100 m² (i.e. an aspect ratio of 36). The load may be from 5 to about 30 tons. The wing is supported by a main strut system 4 which supplies a portion of the lift. The C_D resulting from the C_L of the strut system is very low, and the lift to drag ratio of the whole is practically equal to

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that of the wing. (The same remark applies to the tail unit and to tandem wings).

In this construction a pair of intermediate struts 5 is also used to support the wing 2.

This machine, powered with an engine of 1300 HP fitted with a turbo-compressor and a mechanical compressor, can climb to 20,000 m. with two passengers and a photographic outfit. The power utilized at this altitude for a speed of 300 km. per hour and a weight of 5 tons is 240 HP.

Powered with engines of a total power of 3000 HP and loaded with 25 tons, it can carry 12 tons of useful load to a distance of 1200 km., 10 tons to 4000 km., and 7 tons to a distance ranging from 5000 to 6000 km. The power necessary for flight at the take off is only 780 HP. With 3 tons of useful load, it can remain in the air more than three days at an average speed of 200 km. per hour.

These examples have no limitative character and the various bracing arrangements usually employed may be applied to high aspect ratio wings, including multiplane systems.

In certain cases and as above indicated, the torsional stresses in the wing system may be supported by the bracing device if the latter can be strained in bending in its plane. In other cases, according to another feature of my invention, I provide a stabilizing plane (for example as at 15 in Fig. 5) at the rear of the wing; this plane, which is carried by the wing itself, may extend over the whole or a portion of the span thereof and may be either continuous or discontinuous. It may include either only a movable part or a fixed part, or both a fixed part and a movable part. The object of this plane is to stabilize the portion of the wing behind which it is placed, by directly compensating for the torsional stresses that result from displacements of the centre of pressures as a function of the incidence, instead of causing these stresses to be transmitted, as is usual, to the central portion of the wing and the fuselage.

The movement of the movable part of the stabilising plane, if such a part exists, is intended to give, through the action of the pilot, a predetermined incidence to the portion of the wing behind which it is located, the balancing of the whole of the wing and the tail unit being thus ensured for the chosen incidence.

According to yet another feature of this invention, I may provide a single wing frame extending over the complete span or compose this frame of several sections juxtaposed in the direction of the span. Each section may be reinforced by metallic plates, constituting a portion of the wing covering or skin, and located at places where the compression or tension components of the bending stresses are maximum. These sections may be solid or be hollowed out, made of wood or of a moulded plastic material, or of a light or extra-light metal or alloy, while the reinforcement plates are preferably of an aluminium alloy such as that known under the Registered Trade Mark of "Duralumin" or of steel, and are located on the outer and/or inner face of the wing, where the stresses are maximum. These plates may be fixed to the member or members forming the wing frame in any suitable manner, for instance by nailing, screwing, riveting, glueing welding, and so on.

A particularly advantageous embodiment of this wing construction is illustrated by Figs. 5 and 6. The wing frame 12 is here made as one piece, for instance of wood. It is hollowed out at 13 to reduce its weight. At the parts of the wing where the shape is more complex, the surface of the frame 12 forms part of the wing skin, for instance at the leading edge 12*a*, at the trailing edge, or at the wing tips 12*b*, where the stresses are small. At the parts of lesser stress, i.e. most of the upper and under sides of the wing, a covering is provided by reinforcement plates 14, the ribs formed by frame 12 across the hollows 13 serving to prevent warping of the plates.

It should further be noted that frame 12 supports most of the forces of the plane of the wing, co-operates in the resistance to torsion and supports all the local stresses external to the wing, such as those produced by fixation to the fuselage, strut fixations, front slot supports, if they exist, and rear flap supports.

When the frame is constituted by several sections, each made as a single piece, it is of advantage to provide a clearance between two adjacent sections, in order thus to avoid the excessive stresses that might otherwise be produced by expansion due to temperature variations or elastic elongation of the reinforcement plates.

For the sake of the efficiency of the wing and struts systems, the total lift thereof should be distributed along the span, and as far as possible it should be equivalent to that obtained with a wing of elliptic outline in plan view. Hence according to a feature of my invention, I so arrange the strut system as to obtain the desired variation of lift along the span and thus enable the portion of the wing

between the points of fixation thereto of struts 1 to have a substantially uniform profile, chord and incidence over its whole span.

To avoid discontinuity in the distribution of the lift at the points of junction of struts 1 with wing 2, the lift of the strut sections located close to said points of junction must be made very small or equal to zero. In some cases the desired distribution of the total lift can be achieved by giving the strut sections a uniform direction and depth such that the lift of the sections located near the points of junction with the wing is zero, whatever be the incidence, due to the deviation undergone by the airstream in the vicinity of the wing, whereas the strut sections of the same direction and the same depth but located at a greater distance from these points of junction supply the desired supplementary lift.

However, in most cases, the supplementary lift thus obtained is insufficient to ensure the optimum distribution of the lift, in which event either the incidence of the strut sections is varied along the struts, i.e. so that the angle between each strut section and the corresponding wing section becomes greater the further this strut section is located from the point of junction of the strut with the wing, or the length of the chord of the strut sections is made greater the further this section lies from the point of junction.

However, the application of this second alternative is limited in many cases by the need to design the strut sections with a chord at their stubs which is sufficient to oppose torsional stresses. Thus in the embodiment of the invention illustrated by Figs. 7 to 12 use is made of struts 1 of variable incidence and uniform chord.

In Figs. 9 to 12, which designate the direction of the various sections of a strut 1 illustrating this point, the section which is close to the fuselage has an angle of incidence equal to zero, whereas the section located near to the junction with the wing has an angle of incidence of −2°, the angle of incidence varying gradually and having the value −0.40° in Fig. 11 and −1.20° in Fig. 10.

According to another feature of my invention, the strut sections located close to the point of junction of each strut with the wing are given a shape and an incidence such that the mean line of these strut sections conforms as far as possible to the shape of the airstream in the vicinity of this point of junction, account being taken of the deflection caused by the thickness of the wing. Furthermore, the strut sections are advantageously given, close to the wing, a thickness as small as is permitted by the strength of the materials, for instance equal to, or smaller than, 8% of the chord of the strut section.

Thus, near the point of junction of each of the struts with the wing, the surface of the strut facing the wing is approximately parallel to the portion of the underside of the wing close to which it is located, which involves a substantial reduction of the drag. The strut sections at a greater distance from the point of junction with the wing may be of greater thickness.

Preferably the sections of the struts located near the points of junction with the wing are given an aerofoil profile having an upwardly concave mean line (see Fig. 9), whilst the strut sections at a greater distance from the point of junction of the strut with the wing may be given a symmetrical shape (see Fig. 12) or an upwardly convex shape. In this case, the profile preferably changes gradually along the strut.

According to yet another feature of my invention, I ensure a suitable distribution along the span of the lift of a high aspect ratio wing (15 or more) by combining with this wing a lift increase device which preferably extends over the whole span of the wing, this device having a relatively low profile drag.

By this means I obtain not only a low take off and landing speed, despite the use of high wing loadings, but also provide for taking off, climbing and flying with low power, the lift increase device being utilized either fully or partly.

An example of a construction for this purpose is indicated in Figs. 15 and 16. Here use is made of flaps 113 of the Fowler type (see Fig. 16) suited to the particular wing profile used and chosen for their lower profile drag ($C_{Dc}=0.02$ approximately) for lift coefficients of about 2 or 2.5.

It should be noted here that Fowler flaps are guided by slideways (not shown in the drawings) by means of which they are given combined pivoting and rearward displacements.

The Fowler flaps may occupy about ⅔ of the span of the wing, whereas the remainder of the span is occupied by ailerons 114 which are pivoted downwardly together with the flaps. However, the mean pivoting angle of the ailerons is smaller than that of the flaps. The difference between these angles is so chosen as to permit a suitable distribution of the lift to be obtained along the wing in the direction of its span. The ratio of the angular displacement of the flaps to that of the ailerons may be for

instance such that, for a pivoting of about 20° of the flaps, the mean pivoting of the ailerons is about 12°.

I can thus obtain, for instance for a lift coefficient of 2 and a geometrical aspect ratio of 30, a total drag coefficient of the wing of about 0.06 only, this giving a lift to drag ratio of about 33 and a power coefficient of 2000, thus permitting take off, climbing, and flying with one or more engines stopped, with a lower power. By pivoting the flaps to 40° or more, the lift coefficient can, as on aeroplanes fitted with a lift increase device of the usual type, be raised to values as high as 3 and even more.

The control system illustrated by Figs. 15 and 16 may, for instance, be employed to obtain the simultaneous pivoting of flaps 13 and ailerons 14.

In this system cranks 115, which control both the pivoting and sliding movement of flaps 113, are each connected by a link 116 with one end of a lever 117 which is centrally pivoted about a fixed pin 118 and is hinged at its other end on a nut 119. The two nuts 119 of the two levers 117 coact with a right and left handed screw 120—121, driven by a crank 122 through the intermediary of a chain 123 and a common pinion 124.

Rotation of crank 122 causes levers 117 to pivot in opposed directions, thus pivoting flaps 113 located on either side of the plane of symmetry of the aircraft, in the same direction and through the same angle.

The ailerons 114 are each connected to a bell crank lever which in turn is connected through a link 126 with one end of a lever 127, the other end of which is pivoted at 128 to the lever 117 of the corresponding flap 113 at a point located between the pivot axis 118 of this lever 117 and the hinge provided between the corresponding link 116 and this lever 117. Furthermore both levers 127 are pivoted at 129 to the respective ends of an equalizer bar 130 carried, at its middle point, by one end of a lever 131 which is pivoted about an axis 132 and the other end 133 of which is hinged to a control rod 134.

By moving the rod 134, with levers 117 stationary, the ailerons are made to pivot in opposite directions. Rod 134 therefore forms part of the banking control means. By operating the crank 122, the levers 127 are caused to pivot in opposite directions about their axis 129, which produces the pivoting of the ailerons both in the same direction. However, by suitably selecting the position of the axes 128 on levers 117, the ratio of the pivoting displacements of the ailerons 114 are adapted to those of the flaps 113, so as to obtain, approximately at least, the desired distribution of the lift along the span of the wing.

A lift increase device extending at least approximately over the whole span of the wing may also be formed by a suction and/or blowing device, which can be controlled, near the wing tips, in such manner as to play the part of ailerons.

I vary the intensity of the suction or of the blowing action in such manner as to obtain, approximately at least, a given distribution of lift along the span of the wing. By combining this lift increase device (which is also characterised by a very reduced profile drag coefficient) with aspect ratios of 30 or more, it is possible to obtain extremely high lift to drag ratio and power coefficients, even taking into account the power used to produce the power suction and/or blowing action.

According to a still further feature of my invention, the wing is constituted by two separate shells 104 and 105, Fig. 13, one forming the upper side of the wing and the other the underside thereof, these shells being connected together at the front and at the rear of the wing. Each of these shells is made up of a skin which determines the outer shape of the shell, by stringers 106, 107 running parallel to the span on the inside of the wing, these stringers stiffening the skin and co-operating therewith in resisting vertical bending stresses, and finally by ribs 108 and 109 which are substantially perpendicular to the stringers and maintain the desired streamlined shape of the wing.

The stringers 106 and 107 may have various sections besides those indicated by Fig. 13. The ribs 108 and 109 are preferably of Z-shaped section (Fig. 14) and are provided with openings 108*a*, 109*a* at the place where they cross the stringers of the respective shell, the shape of these openings corresponding to that of the section of the stringers passing through them. Preferably, to enable each rib to be of relatively considerable depth, these ribs are so disposed in each of the corresponding shells that, after assembly, the ribs of one of the shells enter between those of the other shell so that, in lateral projection in the direction of the wing span, the ribs partially overlap one another (see Figs. 13 and 14).

The ribs 108, 109 are now directly connected to one another, and the shells are only interconnected by their skins at the front and at the rear of the wig, any suitable means being employed at this end, for instance welding, screw bolts, or rivets.

Thus, in a preferred embodiment, the

front edges of the two shells are secured to a reinforcing element 110 of gutter-shaped section which serves both to assemble the two shells at the front part of the wing, and to reinforce the leading edge thereof. The interconnection of the two shells at the rear of the wing is preferably obtained by means of two angle irons 111, 112, having rearwardly extending wings applied together and secured to each other by means of rivets, by welding, or the like and fixed one to the rear edge of the upper shell and the other to the rear edge of the lower shell of the wing.

When the shells are assembled by riveting or welding, it is preferred that the leading edge is first secured, the two shells being meanwhile moved slightly away from each other at the rear so as to enable the riveting block or the electrode of the welding machine between the two shells to be introduced.

The construction of the wing described above is particularly easy to carry out in the case of high aspect ratio wing systems. In these wing systems, the bending stresses are relatively high as compared with the shearing or torsional stresses, so that it is necessary to use relatively thick metal sheets for the skin, which may then easily resist, either alone or with a continuous reinforcement, the shearing and torsional stresses.

Hereafter, in the claims, reference is made to the wings of an aircraft. It is, however, to be understood that this plural term also includes the case in which the wings form part of a single wing spanning the whole width of the machine.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A power propeller aircraft having fixed wings and external bracings therefor, said bracings serving as auxiliary lifting surfaces and the aspect ratio of the whole lifting surfaces (i.e. b^2/S are herein defined) is not less than 15 under all circumstances of flight, and the wing loading (including that of the auxiliary lifting surfaces) being not less than 80 kgs. per square meter.

2. An aeroplane according to claim 1, further including a lift increase device of low profile drag coefficient extending over at least a substantial portion of the wing span and adapted to produce a predetermined non-uniform distribution of the lift along said span.

3. An aircraft having fixed wings, external bracing struts for the same, said struts being of aerofoil section and the wings and struts having an overall aspect ratio of not less than 15, and lift increase flaps pivoted on said wings, the wing loading of the aircraft being not less than 80 kgs. per square meter.

4. An aircraft according to any of claims 1 to 3, including a lift increase device in the form of flaps mounted at the rear of the wings along an intermediate section of the span thereof, and ailerons arranged at the rear of the wings laterally of said flaps, control means being provided for operating said ailerons either differentially for lateral control, or simultaneously with said flaps, in the latter case with a lesser amplitude of movement than that of the flaps.

5. An aircraft according to any of claims 1 to 3, including a stabilising plane extending over at least a portion of the wing span and connected to the wings at a plurality of points along said span.

6. An aircraft according to any of the preceding claims, in which the wings are connected to a fuselage by streamlined bracing struts, these struts each being shaped and disposed so that the mean line of the cross section thereof adjacent its junction with the corresponding wing conforms substantially to the airflow along the wing.

7. An aircraft according to claim 6 in which the thickness of the strut cross section progressively decreases from the fuselage end to the wing end of the strut.

8. An aircraft according to any of claims 1 to 5, in which the wings are connected to the fuselage by streamlined bracing struts, these struts being of varying incidence and-or depth along their length so as to give a continuous non-uniform distribution of the total lift over the portion of the wing span between the points of connection of the wings to the struts.

9. An aircraft according to claim 8, in which each strut has a lift coefficient which is zero at or adjacent the point of its connection to the corresponding wing.

10. An aircraft according to any of the preceding claims, in which the wings are formed by a single frame, or a plurality of interconnected frames extending along the length of the span and having a clearance between each adjacent pair, and by a frame covering of reinforcing plates.

11. An aircraft according to claim 10, in which the said frame, or each said constituent frame, is integrally formed as a hollowed-out element.

12. An aircraft according to any of claims 1 to 9, in which the wings are formed from two shells, respectively forming the upper and lower sides of the wing,

which are interconnected at the leading and trailing edges of the wing.

13. An aircraft according to claim 12, in which the shells are reinforced by stringers extending in the general direction of the wing span, and ribs arranged in the fore and aft direction of the wing.

14. An aircraft according to claim 1 substantially as herein described with reference to Figs. 1 and 2, Figs. 3 and 4, Figs. 5 and 6, Figs. 7 to 12, Figs. 13 and 14, or Figs. 15 and 16 of the accompanying drawings.

Dated the 30th day of July, 1946.

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[This Drawing is a reproduction of the Original on a reduced scale.]

Fig.1.

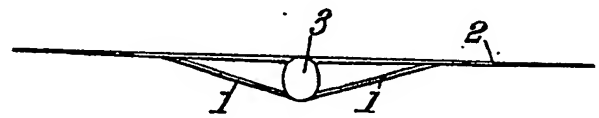


Fig.2

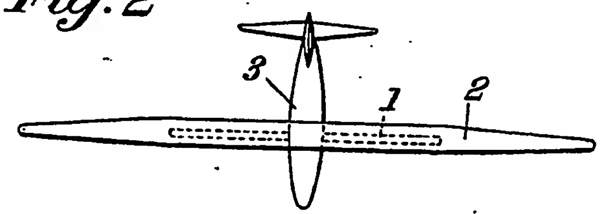


Fig.3.

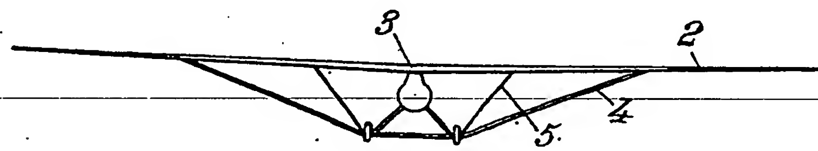


Fig.4.

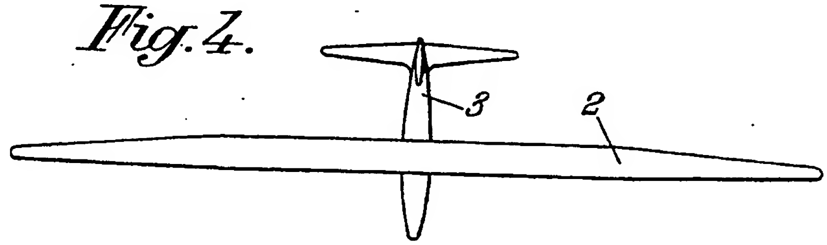


Fig. 7.

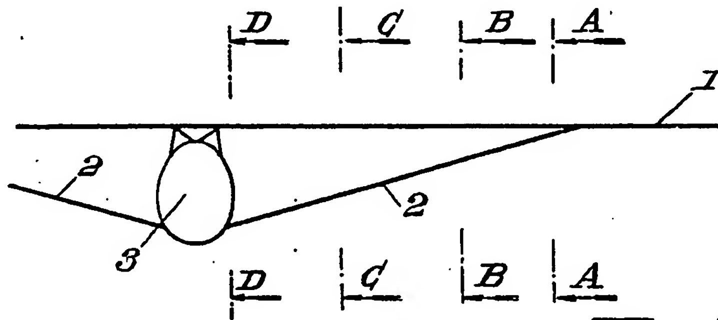
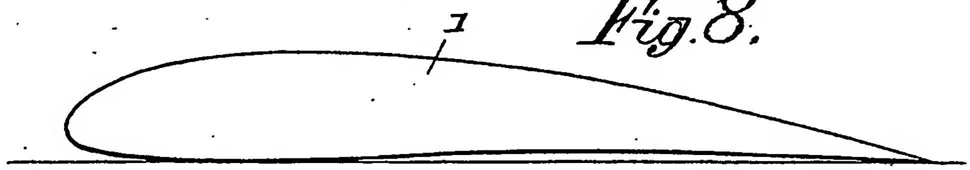


Fig. 8.



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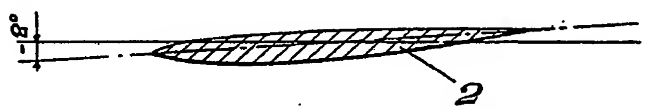

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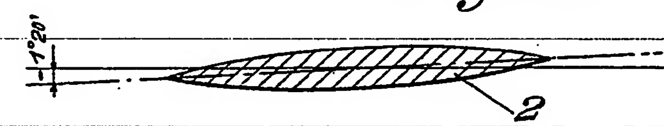

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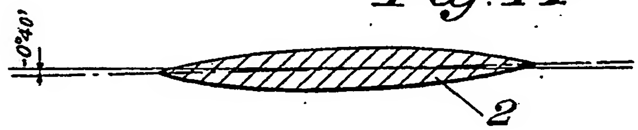
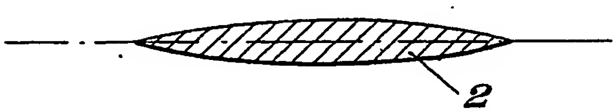


Fig. 12



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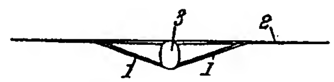
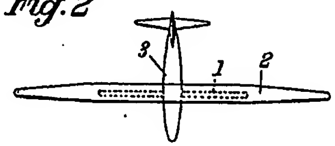


Fig. 2



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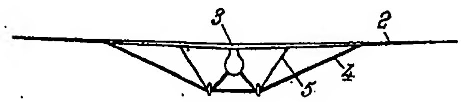

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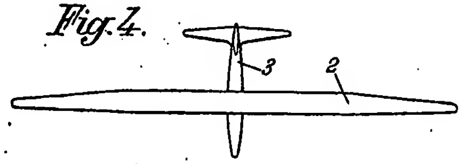

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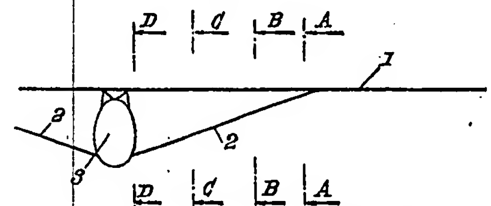

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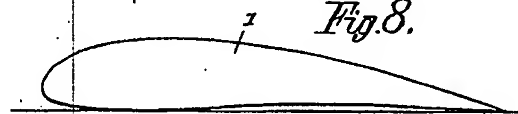

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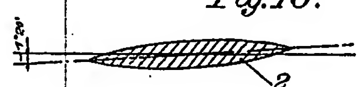

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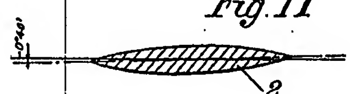

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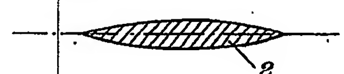

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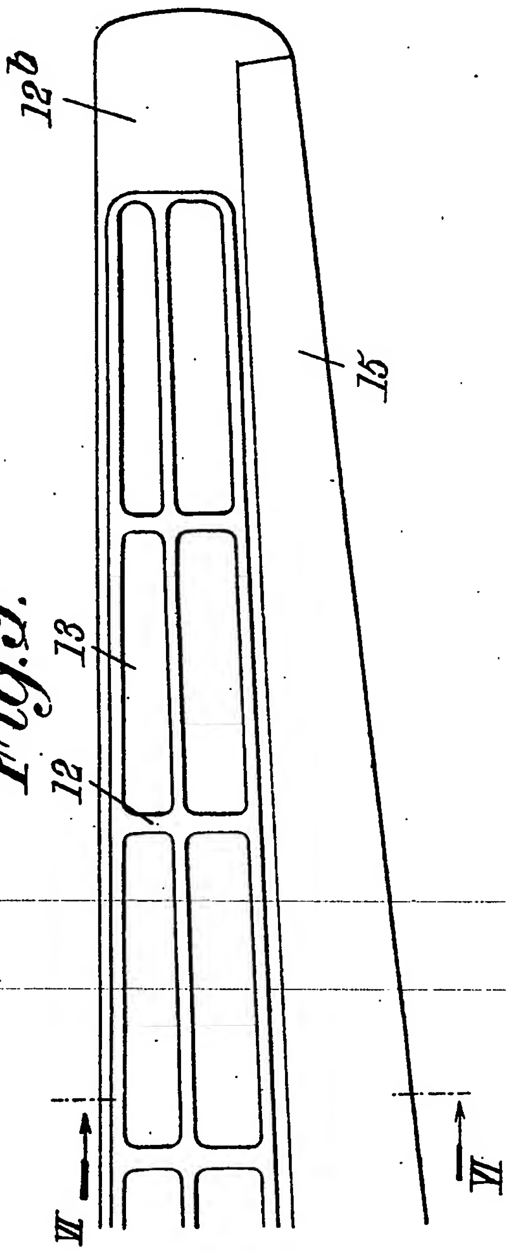

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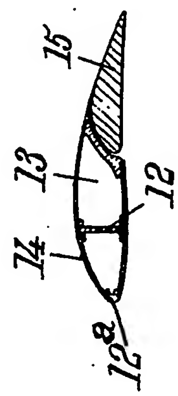

Fig.6.

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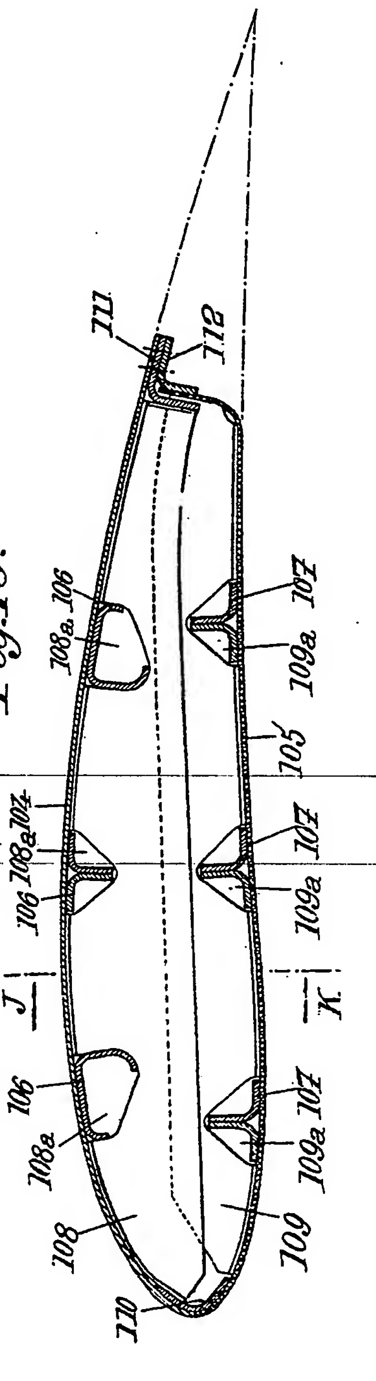

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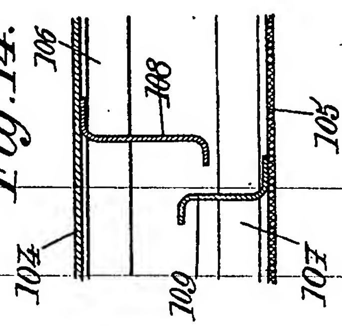

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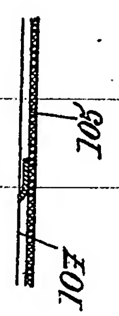

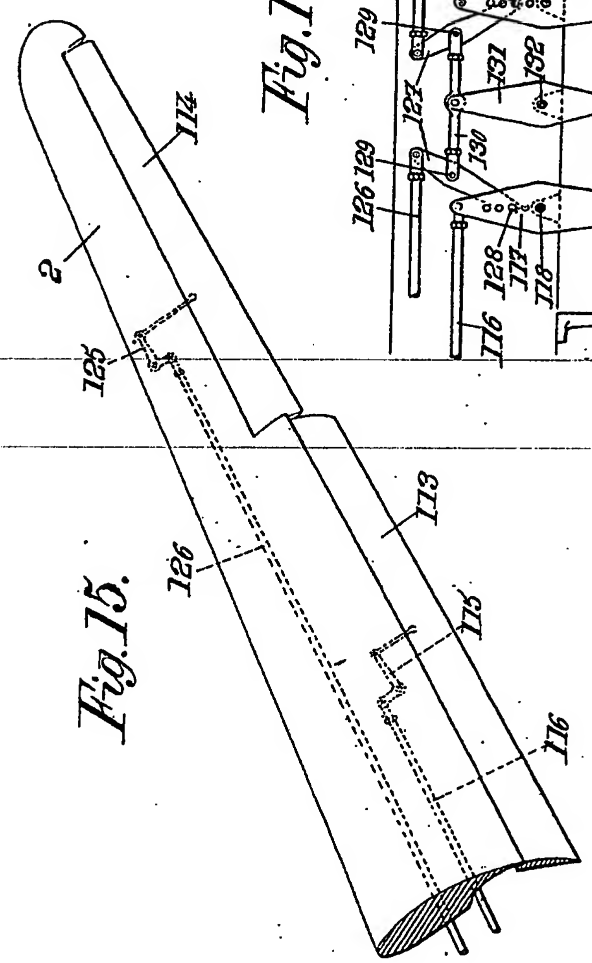

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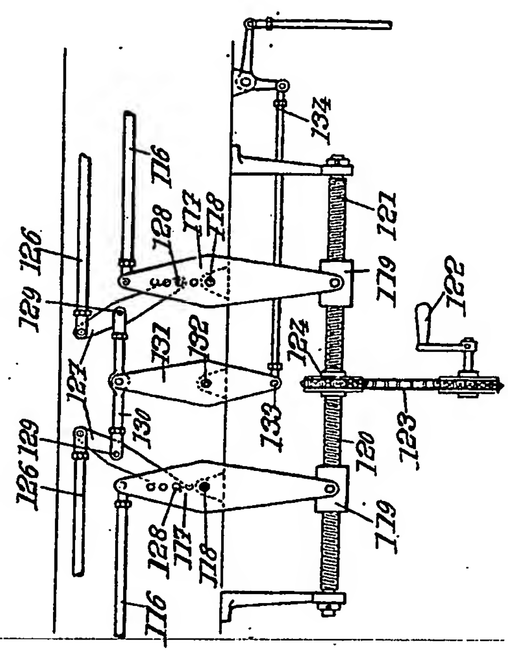

Fig. 16.

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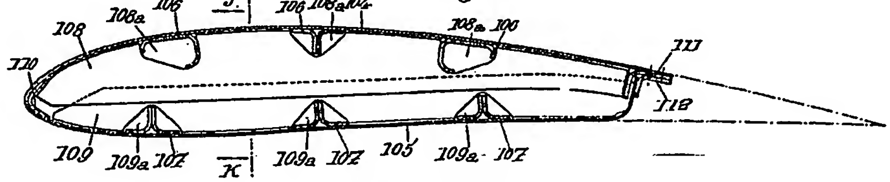
SHEET 4

Fig. 13.



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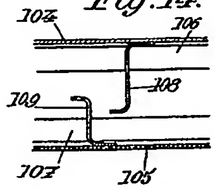

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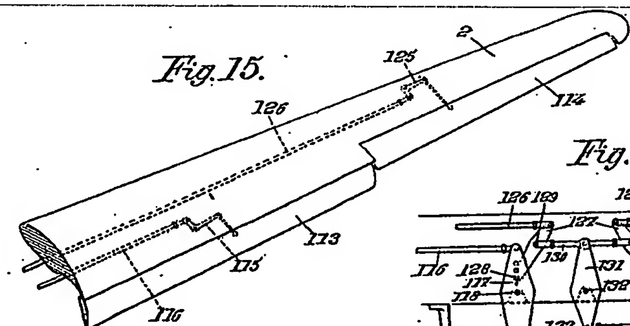

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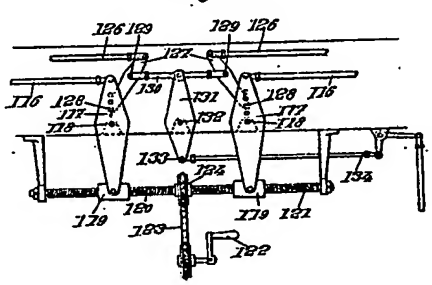

5 SHEETS
SHEET 5

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